CalFed Drinking Water Quality Program

Bromate Control with CO_2 Addition

Alameda County Water District
Water Quality & Treatment Solutions, Inc.

SCOPE OF WORK

August 30, 2002

This project will be conducted at ACWD's 28-MGD water treatment plant in Fremont, California. The plant includes a dual-train preozone contactor with five chambers per train. This unique feature allows for side-by-side comparison of the two CO_2 feed systems under identical water quality conditions. Ozone is generated from ambient air, and is currently added in the first and second chamber of each contactor.

This project has two primary objectives:

1. Gather performance data and conduct specific testing to evaluate the design and operational issues associated with the use of CO_2 for reducing bromate formation during ozonation of SWP water, and

2. Conduct a side-by-side comparison of two CO_2 feed methods that can be used at full-scale ozone plants.

To achieve the objectives of this project, the following tasks will be conducted:

Task 1 - Prepare & Submit a Testing Plan

Task 2 - Prepare & Submit a QA Project Plan

Task 3 - Make Necessary Plant Modifications

Task 4 - Conduct Full-Scale Testing

Task 5 - Conduct Economic & Data Analysis

Task 6 - Prepare & Submit Monthly Letter Reports

Task 7 - Present Results at One National Conference

Task 8 - Prepare & Submit Project Final Report

Task 9 - Make Presentation to CalFed

Task 1 – Prepare & Submit a Testing Plan. In Task 1, the project team will prepare a detailed Testing Plan that outlines all project testing activities. This plan will include a detailed experimental design, detailed sampling locations and frequency, and sample analyses. The Plan will also include Data Log-Sheets to be used by the plant operators to record the necessary operational and monitoring information collected during each test. The Testing Plan will build on the specific discussion included in this proposal. A draft version of the Testing Plan will first be submitted to ABAG for submittal to CalFed or review and comment. Once CalFed's comments are incorporated into the Testing Plan, its implementation at the treatment plant will commence.

Task 2 – Prepare & Submit a QA Project Plan. Parallel with the development of the Testing Plan in Task 1, the project team will conduct Task 2, which includes the preparation and submittal of a Quality Assurance Project Plan (QAPP) to ABAG for submittal to CalFed. The QAPP will adhere to the requirements of the Department of Water Resources (DWR). However, it is recognized that the scope of this project is quite limited and does not include significant collection and analysis of environmental samples. Therefore, the QAPP is anticipated to be brief.

Task 3 – Make Necessary Plant Modifications. In parallel with the development and review of the Testing Plan (Task 1) and the QAPP (Task 2), ACWD maintenance staff and contractor will conduct Task 3, which includes the construction of the necessary modifications at the treatment plant. These will include a modification to the CO_2 injection system to one of the two contactors. Figure A.1 shows a schematic of the CO_2 feed setup to the two ozone contactors. For Contactor #2, CO_2 will be fed directly into the ozone feed gas line. For Contactor #1, CO_2 gas will be fed, under pressure, to a side water stream, which is then blended back with the main water flow before it enters the ozone contactor. Modifications will also be made to allow a sufficient amount of ozone-free air to be applied to the last cell of one of the ozone contactors for the purposes of stripping CO_2.

Task 4 – Conduct Full-Scale Testing. Once the necessary modifications to the plant are made, implementation of the Testing Plan will commence. Testing and monitoring results will be recorded on the Data Log-Sheets included in the Testing Plan. The results will then be inputted into pre-formatted EXCEL spreadsheets, and analyzed appropriately. Analysis of the results will occur on a weekly basis so that any problem areas or data gaps are swiftly identified, and correction actions are immediately relayed to the plant operators.

As shown in Figure 1, the two CO_2 feed systems will be evaluated side-by-side. The following specific tests will be conducted in this project:

1. Impact of CO_2 Dose on Bromate Formation
2. Impact of Subsequent CO_2 Stripping on Finished-Water pH adjustment Cost

Test #1 – Impact of pH Depression with CO_2 Addition on Bromate Formation. As the title implies, this test will focus on establishing the relationship between the CO_2 dose needed to achieve a certain pH depression and bromate formation with various ozone doses applied to SWP water. Table 1 lists the proposed experimental matrix of target pH

values and ozone doses evaluated. CO_2 doses to each train will be adjusted to achieve the target pH values of 7.5, 7.0, and 6.5 in the ozonated water. For each target pH, three ozone doses will be evaluated. The doses will be selected to achieve three levels of *Cryptosporidium* inactivation: 0.5 log, 1 log, and 2 logs, unless deemed non-feasible within the operational constraints of the water treatment plant. During each test, data will be gathered on the CO_2 dose required to achieve the target pH, water temperature, ozone dose, ozone residual profile through the contactor, influent and effluent water pH, and bromate levels formed. It is noted that each test will be conducted on each train using the two CO_2 feed methods.

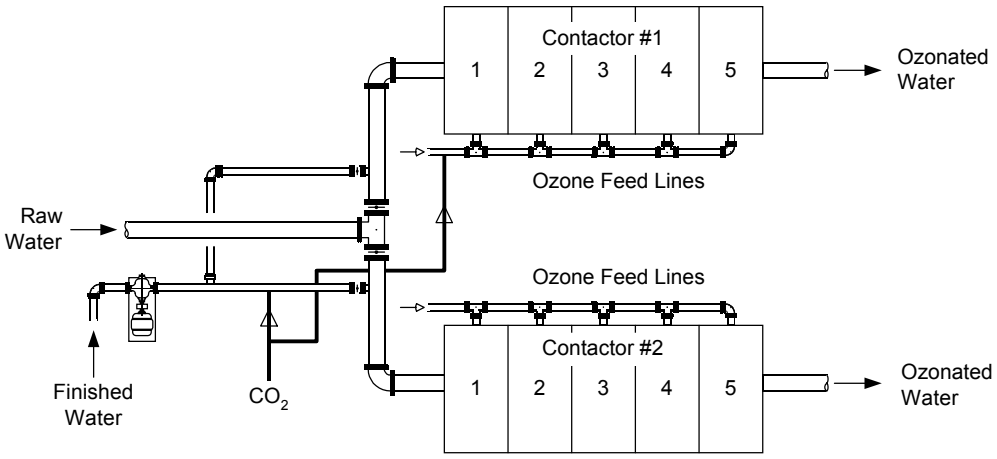

Figure 1 – Schematic of the Planned & Proposed CO_2 Injection System

Table 1 –Testing Matrix for Evaluating the Effect of pH Depression with CO_2 Addition on Bromate Formation

Test #	Target pH	*Crypto.* Log Kill
1-A	7.5	0.5
1-B	7.5	1.0
1-C	7.5	2.0
2-A	7.0	0.5
2-B	7.0	1.0
2-C	7.0	2.0
3-A	6.5	0.5
3-B	6.5	1.0
3-C	6.5	2.0

Test #2 – Impact of Subsequent CO_2 Stripping on Finished-Water pH Adjustment Cost. As discussed earlier in this proposal, we plan to evaluate the idea of adding compressed air in the last chamber of the ozone contactor to strip out some or all of the added CO_2. The primary goal of this action is to reduce the dose (and thus cost) of the caustic soda used to raise the finished-water pH. Since CO_2 stripping increases water pH, any CO_2 removal achieved will result in a reduction in the caustic soda dose required to raise the finished water pH in the plant. The cost of caustic is almost four times the cost of either CO_2 or sulfuric acid. Therefore, great cost reduction can be gained even from partial stripping of the dissolved CO_2 in the last chamber. This idea has another secondary advantage, which is reducing the treated water salinity concentration. For example, if ACWD uses sulfuric acid and caustic soda to achieve bromate control, it will increase its total dissolved solids (TDS) concentration by about 30 mg/L. However, if it adds CO_2 and then strips it in the last chamber, it will achieve the same bromate control with no increase in TDS concentration. Specific tests will be conducted to evaluate the impact of adding compressed air to the last chamber in the ozone contactor on CO_2 stripping and the resulting water pH. The data obtained from these tests will be used to evaluate and compare the economics of using compressed air versus caustic soda for pH adjustment. The tests will evaluate a range of air-to-water flow ratios and record the resulting pH and corresponding caustic soda dose required to raise the finished water pH to 8.1.

Task 5 – Conduct Economic & Data Analysis. After the results are gathered from both types of tests and analyzed, an economic analysis will be conducted for both CO_2 injection systems. The analysis will address three primary areas: First, compare the cost of in-line CO_2 injection system to that of adding CO_2 directly into the ozone gas feed line. Second, compare the cost of adding sulfuric acid for pH adjustment to that of adding CO_2. Third, compare the cost of using a combination of CO_2 stripping and caustic soda for final pH adjustment to that of using only caustic soda.

Task 6 – Prepare & Submit Monthly Letter Reports. During the project progress, the project team will prepare and submit to ABAG for submittal to CalFed's project manager monthly letter progress reports describing the work completed during the previous month, as well as the work planned for the following month. The reports will also include an update of the project schedule and budget.

Task 7 – Present Results at One National Conference. The key project engineers, Issam Najm and Susan Teefy, will prepare and make presentations of the project effort and results at one national technical conference and one local technical conference. The purpose of these presentations is to disseminate the information gained from the CalFed-funded work.

Task 8 – Prepare & Submit Project Final Report. The testing results and the economic analysis will be presented in a draft project report to be submitted to ABAG for submittal to CalFed for review and comments. After receipt of CalFed's comments, the report will be revised and 10 copies of the final project report will be submitted to ABAG for submittal to CalFed, along with one electronic copy in '.pdf' format.

Task 9 – Make Presentation to CalFed. Along with the submittal of the draft project report to ABAG and CalFed, the two key project engineers, Issam Najm and Susan Teefy, will make a presentation of the project results to CalFed's Drinking Water Subcommittee (or another group of CalFed's choice) in Sacramento.